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IMPLEMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION	1b. RESTRICTIVE MARKINGS														
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.														
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE															
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S) AFOSR - TR. 89 0521														
6a. NAME OF PERFORMING ORGANIZATION University of Washington Depart. of Aeronautics & Astronautics	6b. OFFICE SYMBOL (if applicable)	7a. NAME OF MONITORING ORGANIZATION AFOSR													
6c. ADDRESS (City, State, and ZIP Code) Seattle, WA 98195	7b. ADDRESS (City, State, and ZIP Code) BLDG 410 BAFB DC 20332-6448														
8a. NAME OF FUNDING/SPONSORING ORGANIZATION AFOSR	8b. OFFICE SYMBOL (if applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER F49620-79-C-0141													
8c. ADDRESS (City, State, and ZIP Code) BLDG 410 BAFB DC 20332	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. 61102F PROJECT NO. 2340 TASK NO. A4 WORK UNIT ACCESSION NO.														
11. TITLE (Include Security Classification) RESONANCE IN WEAKLY NONLINEAR SYSTEMS															
12. PERSONAL AUTHOR(S) J. Kevorkian															
13a. TYPE OF REPORT Final	13b. TIME COVERED FROM _____ TO _____	14. DATE OF REPORT (Year, Month, Day) May 1980	15. PAGE COUNT Three												
16. SUPPLEMENTARY NOTATION															
17. COSATI CODES <table border="1"><tr><th>FIELD</th><th>GROUP</th><th>SUB-GROUP</th></tr><tr><td> </td><td> </td><td> </td></tr><tr><td> </td><td> </td><td> </td></tr><tr><td> </td><td> </td><td> </td></tr></table>	FIELD	GROUP	SUB-GROUP										18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)		
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19. ABSTRACT (Continue on reverse if necessary and identify by block number)															
<p style="text-align: center;">DTIC ELECTE APR 26 1989 S D <i>by</i></p>															
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS			21. ABSTRACT SECURITY CLASSIFICATION unclassified												
22a. NAME OF RESPONSIBLE INDIVIDUAL			22b. TEL. # _____ 22c. OFFICE SYMBOL 767-5025 NM												

Final Scientific Report for
Contract No. [REDACTED] F49620-79-C-0141
Resonance in Weakly Nonlinear Systems

Submitted by J. Kevorkian
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Seattle, Washington 98195

During the contract period June 1, 1970 - May 31, 1980, the principal investigator in collaboration with two graduate students conducted research in the four areas outlined in the contract. The progress of this research is summarized below.

1) Adiabatic Invariants for Nearly Periodic Hamiltonian Systems Passing through Resonance;

This research concerns the existence of global adiabatic invariants which survive resonance passage. We have adapted techniques from Hamiltonian perturbation theory with modern singular perturbation analysis to derive such invariants. Some of these results are reported in [1] and deal with a system of two degrees of freedom for which an explicit expression for the adiabatic invariant is derived.

In [1], we first review the classical technique for calculating adiabatic invariants and exhibit the occurrence of zero divisors in the results as a certain critical term evolves slowly through a resonance condition. We then isolate the coordinate associated with the singularity and remove the remaining coordinate from the Hamiltonian to any desired order by successive canonical transformations. The momentum conjugate to the removed coordinate

is the global adiabatic invariant, and the reduced Hamiltonian is then solved by constructive and matching three multiple variable expansions which describe the solution before during and after resonance passage.

2) Passage through Resonance

The principal investigator was an invited speaker at an advanced seminar on singular perturbations and asymptotics held at the Mathematics Research Center, University of Wisconsin - Madison during May 28-30, 1980.

The lecture gave a survey of the topic of passage through resonance including some of the recent results reported in [1] as well as earlier work concerning sustained resonance for reentry problems. The proceedings of this seminar will include this survey article, [2].

3) Resonant Wave Interactions

Using the Klein-Gordon equation as a mathematical model for weakly nonlinear dispersive systems we have completed a study of resonant wave interactions. We express the solution as a multiple variable expansion involving both spatial and temporal slow variables and derive results which remain uniformly valid for resonant combinations of the wave numbers.

This work is in its preliminary stages and will be continued during the next grant period. We plan to study problems of resonance passage in nonlinear acoustics analogous to those discussed in Sec. 1

4) Entry Dynamics

A necessary first step in studying entry dynamics analytically is an accurate mathematical model of high altitude trajectories. The simplest non-trivial example occurs for the case of a spherical (non-lifting) satellite entering with no control an exponentially varying atmosphere.

Reference [3], carried out under the present contract, reports on this problem. Multiple variable expansions are used to describe the osculating orbital elements and these are in excellent agreement with numerical results. In view of the good accuracy of this model and procedure we plan to study more complicated problems within the same framework.

References

1. J. Kevorkian, "Adiabatic Invariance and Passage through Resonance for Nearly Periodic Hamiltonian Systems". Submitted to Studies in Applied Mathematics.
2. J. Kevorkian, "Passage through Resonance", To appear in the Proceedings of the Advanced Seminar on Singular Perturbations and Asymptotics", Mathematics Research Center, University of Wisconsin - Madison.
3. A. J. M. Chakravarty, "Orbital Decay Due to Drag in an Exponentially Varying Atmosphere", To Appear in A.I.A.A. Journal of Guidance and Control.

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